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ABSTRACT

The economic growth of the nation is dependent upon the inclusion of minority and underrepresented groups in science, engineering, mathematics, and technology-related careers. This report especially addresses those barriers encountered by Latina students preparing to enter scientific and technical careers. The paper summarizes the research literature that addresses female recruitment and retention in mathematics and science, discusses the results of interviews conducted with Mexican-American youth and their teachers, and describes experience with programs designed to recruit and retain minority and underrepresented groups in mathematics and science. (Contains 23 references.) (WRM)

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"Como que No Puedo!" Strategies for the Recruitment and Retention of Hispanic Females into Mathematics and Science Post-Secondary Programs and Careers

by

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"¡COMO QUE NO PUEDO!" STRATEGIES FOR THE RECRUITMENT AND RETENTION OF HISPANIC FEMALES INTO MATHEMATICS AND SCIENCE POST-SECONDARY PROGRAMS AND CAREERS

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Early in this century, Mexican-Americans who attempted to enter the mainstream of economic and educational attainment faced a dilemma (Garza & Ockerman, 1979). Prior to the 1960's, discrimination, especially access to education, was common. Although discrimination is no longer a major factor toward attaining economic security and education, almost a decade later institutional and cultural barriers still stifle Mexican-American minority completion of pre-college preparatory programs. Eliminating these barriers, although difficult, must be attempted to develop a new generation of scientists, engineers, and mathematicians coming from minority and underrepresented groups who are willing and prepared to enter the science, engineering, mathematics, and technology (SMET) workforce. The economic growth of the nation is dependent on the inclusion of minority and underrepresented groups into SMET careers. This report especially addresses the barriers encountered by minority females preparing to enter scientific and technological fields.

The researchers conducted the study through literature searches that focused on female recruitment and retention in mathematics and science. It also included, in its search, topics such as science and mathematics anxiety, cultural barriers influencing SMET, minority and female learning modalities, teaching methods, and intervention programs. In addition, interviews of Mexican-American youth and their teachers was

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conducted to provide an insight for developing best practice models for female recruitment and retention in SMET. Finally, the researchers' personal experience with programs designed to recruit and retain minority and underrepresented groups, including females, into SMET and into the teaching fields has provided a basis for postulating recommendations to those involved in developing recruitment programs.

Hispanic Female SMET Career Support Systems Model

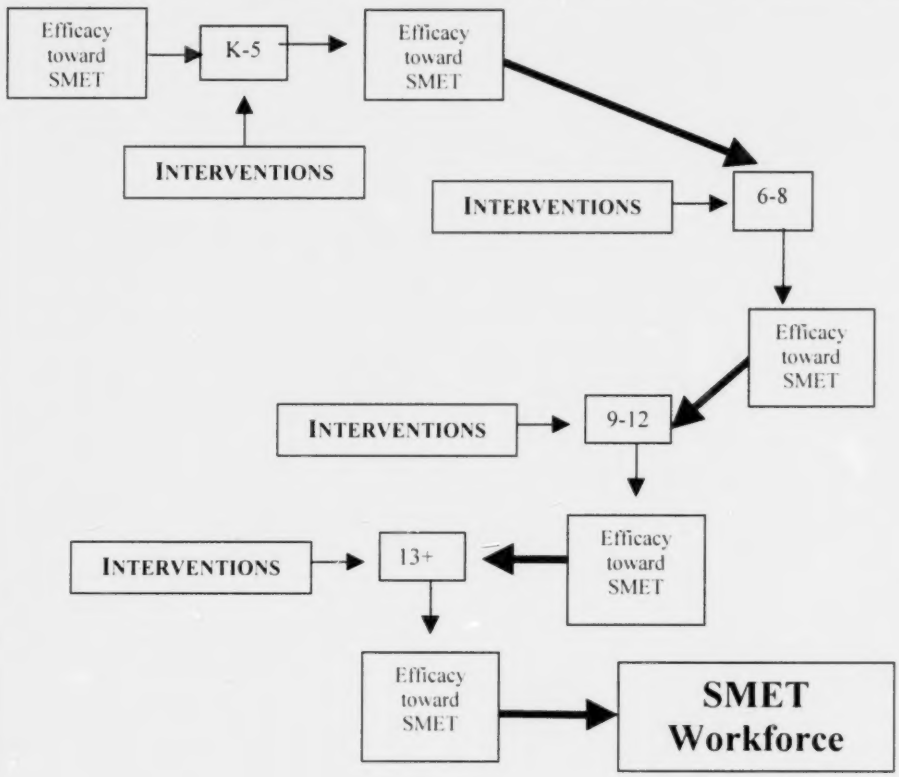
The researchers recognized that a support model for Hispanic females entering SMET programs at all levels needed development and exploration. The model presented here is still under revision and should not be viewed as our final representation of Latina recruitment and retention into SMET. The conceptual framework, at present, incorporates the attitudes and actions of Hispanic females as they first participate in recruitment interventions at the elementary school, middle school, high school, and finally the college level. Perception about future success in SMET is an underlying premise of our thoughts regarding recruitment and retention. Although academic preparation is considered a necessary attribute toward successful entry, the outcome of completing and entering the SMET workforce is a function of family and culture, science and mathematics anxiety, and support systems at the middle school, high school, and college levels. Perceptions about their ability to enter, compete in, and complete programs of study are directly tied to these factors.

The conceptual framework described in Figure 1 represents the resultant interactions of SMET interventions on academic preparation and career choice. At the national, level students, enter the pipeline as they receive support to boost or maintain their attitudes about mathematics and science (Sakai & Lane, 1996). Their belief in their

ability to "do science and math" is affected by their experiences. The model represents the use of interventions that increase student self-efficacy or belief that they can be successful and able to enter the SMET workforce.

The intervention model indicates a continuum from elementary grades through to their university experience and eventually into their career choice. At every grade level

Figure 1. Conceptual Framework of SMET Intervention Model



students may receive interventions. As they receive interventions, their attitudes toward mathematics and science can be translated into a desire to enter SMET careers. In Grades K-5, children receive opportunities that increase their attitudes toward science through a

variety of interventions. The Brownsville school district in south Texas provided funding between 1991 to 1994 for " Science and Mathematics Academies". The academies involved children alongside their parents or an adult learning partner in teacher-designed activities. The academies were implemented at every grade level up through high school. Students left the elementary grades with positive attitudes about science and mathematics. In the case of academies, an added benefit was the requirement of a learning partner, which resulted in the increase of active parental involvement. Interventions such as science and mathematics academies, summer programs, or weekday programs like Family Math or Family Science improved student self-concepts about their science and mathematics ability. Claire (1992) sited that these benefits can be extended to involving high school students with family members in an attempt to change attitudes about science and mathematics at home. The activities provide talented prospective SMET students with support systems that allow them to delay working immediately after high school to pursue post-secondary SMET programs.

A high number of Latina females enter middle school believing in their ability to do science and mathematics when involved in these interventions. Interventions at the elementary level, although few, increase their efficacy as they enter courses that are now offered in a middle school discipline format. If offered, students may take advantage of organizations or programs that specifically cater to them. Such programs like the Hispanic Mother Daughter Program, a program sponsored by the National Aeronautics and Space Administration, provide mathematics and science activities. During the summer, students may be involved in the Texas Pre-freshman Engineering program or TexPREP where they receive a curriculum that includes logic, algebraic structures,

probability and statistics, and a variety of problem-based, hands-on activities (Berriozabal, 1993). This program is steadily becoming a national model for minority student interventions in engineering and mathematics.

During high school, organizations like the South Texas Engineering Mathematics and Science Program or STEMS, provide activities to interested students. The inclusion of females is not a focus, but Latina girls do participate. The activities include guest speakers, field trips, and enrichment activities. Guest speakers often involve Hispanic females as part of their activities. During the summer, the students participate in a program similar to TexPREP. The STEMS activities are broader in scope and include less mathematics preparation.

Schools as Barriers to Science, Mathematics, Engineering, and Technology (SMET) Career Selection

For many years educators have pondered the reasons why Mexican American students fail in school (Ockerman-Garza, 1982). New programs have been introduced in an effort to reduce the number of failures, yet this has not curbed the attrition of these students. Schools have not met their needs. Educators have failed to capitalize on the strengths of these students. Such educational attitudes have contributed to the long history of school failure by underrepresented groups.

Aside from all of the social factors faced by Mexican American students, the barriers imposed by schools may stifle Mexican American completion of pre-college preparatory programs. Some educators feel that the schools have unknowingly contributed to the pattern of failure observed in the nation's schools (Laosa & Henderson, 1993). Further, it is our belief that these barriers impede entry into post-secondary

science, mathematics, and engineering programs. Thus, eliminating these barriers will develop a new generation of underrepresented scientists, engineers, and mathematicians willing and prepared to enter the science, engineering, mathematics, and technology (SMET) workforce.

The composition of schools places female students in situations where expectations are biased away from their femininity. They are often thought of by teachers and often themselves as inferior problem solvers. Further, their teachers have set lower expectations of performance in science and mathematics for this group. Research in middle school algebra has supported providing girls with environments which are less restrictive and more open to their needs (Stutler, 1997). Stutler considers that these classes should be less permeated with societal expectations of performance for these girls.

Different barriers affect the success and incorporation of students into schools. Sosa (1993) considers those barriers that impede entry into mathematics and science based on high expectations, student placement in upper level science and mathematics, increased staff development for teachers to address equity concerns, and taking an advocacy role in testing and grade retention. Of particular interest in Sosa's recommendations is the creation of an equity administrator to identify and work to remove barriers that thwart minority student success. The advocacy of minority and gender groups has suffered setbacks by anti-affirmative action legislation. However, the benefits to female students is documented by several local programs like the Hispanic Mother Daughter Program, South Texas Engineering, Mathematics, and Science Programs, and gender specific science and mathematics academies.

Bernstein (1992) focused on changes between gender in regard to mathematics anxiety as both males and females proceeded through the education system. It examined the feelings of math in students in single parent and nontraditional career preparation programs in relation to selected demographic characteristics. Survey instruments consisted of a brief math test and an attitude scale. At age 12, males felt slightly more math anxiety than females did. However, by age 14, females were more anxious about math than males and this continued up to the age of 19. Eventually both groups exhibited greater math anxiety. Males in the African-American, Hispanic, Asian, and Native American groups exhibited high levels of math anxiety, as did females in the African-American and Hispanic groups. Math anxiety was reduced by students participating in more rigorous coursework. In this study, the actions recommended for confronting math anxiety included asking math instructors to conduct a self-assessment of gender and ethnicity disparities in the classroom, starting a math club for females, and learning the visualization technique of anchoring.

Schools must present themselves as advocates for minorities and females. Learning activities and teaching methods that are more sensitive to these groups at all grade levels must be proposed as part of educational expectations. Career opportunities open to females in science and mathematics must be included in the curricular materials and discussions that occur in schools (Dobson & Hranitz, 1992).

Gender Differences in Learning Styles and Teaching Styles Appropriate for Hispanic Females in Science and Mathematics Courses

Research over the last decade has shown that males and females have different classroom experiences because they approach learning differently. Achievement

expectations for females in some subjects are usually lower, as they are for members of certain racial and ethnic groups and for poor students. As girls progress through school, they are less likely to continue their math education, either taking more rudimentary courses or dropping the subject altogether (Pallas & Alexander, 1983).

Researchers continue to study the different perspectives from which males and females approach learning science and mathematics. Females prefer to use a conversational style in the classroom that fosters group consensus and builds ideas on top of each other (Ong, 1981). Males, on the other hand, learn through argument and individual activity. Most classroom discourse is organized to accommodate androcentric learning patterns. In addition, females are not likely to believe that math has utility in their lives; they see math as unconnected to a relationship model of thinking. Even if they persist in taking math courses, girls are apt to find that they don't like them, and liking the subject is key to success and possibly career selection.

Most classroom structures are supportive of white male, middle-class socialization models and are designed to foster independent non-collaborative thinking. It encourages sex-role stereotype forms of communication such as independence, dominance, and assumption of leadership, in which males have been trained to excel.

Teacher's attitudes must change in order to encourage mathematics achievement. They must understand and respect female learning styles which will help alter classroom discourse to accommodate female participation and provide a message to both males and females that no single learning behavior is greater than another.

Policy makers, science leaders, and science teachers have been searching for new ways of providing quality science learning experiences for female students (Didion,

1997). Our research supports and agrees with the following three reasons for action to address appropriate teaching methods to support Hispanic females in science and mathematics courses.

1. The demographics of K-12 science classrooms in this nation are changing. We must develop proactive models that support this change.
2. A more science literate populace is needed. Currently Hispanics in the U.S. comprise the fifth largest Hispanic population on Earth. Slightly over 30 million individuals live in the U.S. alone.
3. All students must have the opportunity to learn quality science and mathematics. Mathematics and science will be key to success in the future and every person must be able to contribute to society's improvement.

One way of providing a quality science and mathematics education for all K-12 students is through classrooms that recognize multicultural and gender concerns. The literature reveals five dimensions of multicultural education for K-12 classrooms that serve as organizers for science learning and teaching: knowledge construction, content integration, equity pedagogy, prejudice reduction, and empowering school culture (Atwater, Crockett, & Kilpatrick, 1996).

Multiculturalism is needed because of the changing demographics of this nation. In 1973, 20% of the population was a minority, whereas today, 40% of the population is considered a minority. One major problem minorities such as Mexican Americans face is the language barrier, many of them are learning English as a second language and are having a difficult time learning a new language. Science is a course that is often taught totally in English, which makes it very difficult for Spanish speaking students to learn.

This needs to change. ESL must be offered to these students so that they can have a chance to learn and participate in science activities.

Cultural differences in the classroom are becoming more apparent. One classroom can be filled with students from several cultural roots. Teachers need to be more diverse in their teaching styles, and try to explain terms and procedures to students in ways that they might understand and relate to the work or assignment.

Knowledge construction is important because knowledge in science would lead to understanding of natural phenomena acquired through a process in which students learn about scientific values, goals, assumptions, and preconceptions that have cultural meanings. Androcentric and Eurocentric pedagogies are not appropriate to Hispanic females.

Multiculturalists, feminists, and philosophers of science have challenged the traditional thinking about the nature of science. They believe that science has become problematic because its assumptions, preconceptions and limitations reflect the culture and politics of scientists who are mostly white males. The recognition of ethnic and gender contributions is not considered (Love, 1993; Shmurak & Ratliff, 1993).

Higher Education Institutions as Barriers to SMET Career Recruitment and Retention

Where the K-12 institutions may be considered as lacking, institutions of higher education fall way short of making any perceptible changes in their treatment and inclusion of Latina females. As an advocate for equal representation of all groups, Sheila Tobias writes that issues of gender equity have solutions. She believes that the barriers posed to women in the professions are preventable and curable and identifies discrimination at entry level, limited opportunities for advanced study, limited

advancement, role conflict, and role socialization--lack of motivation to persist in the study of mathematics and mathematics-related subjects as barriers that have impacted female entry into SMET (Tobias, 1981). Earlier in this decade, institutions of higher education were considered to serve as a barrier into the professions for those females who have made a decision to pursue university training (McDonald, 1990). Even after considering the latest reports that note that females make up over half of the students enrolled in graduate programs and obtain the majority of masters degrees, problems with sexual harassment and future employment benefits exist (Department of Education Washington DC., 1997).

Outreach programs that support minority female recruitment are so limited in funding that many girls do not receive the benefit of recruitment and support efforts offered by institutions of higher education. In addition, the structure of universities and community colleges does not address the recruitment and retention needs of Latinas. Local initiatives that have supported females and minorities who have attained SEM proficiency will be identified and discussed later in this report. Recommendations will elaborate on initiatives that strengthen female and minority recruitment and retention [(Congress of the U.S. Washington D.C. House Committee on Science and Technology, 1982); (California State Post-secondary Education Commission Sacramento., 1988).

Local Results of Intervening Through Recruitment and Retention Projects. A large number of Hispanic boys and girls enrolled in public schools will unlikely pursue mathematics and science careers. Generally, the system is not established to foster SMET preparation. However, programs that approach recruitment and retention are part of initiatives in some south Texas schools and institutions of higher education. The

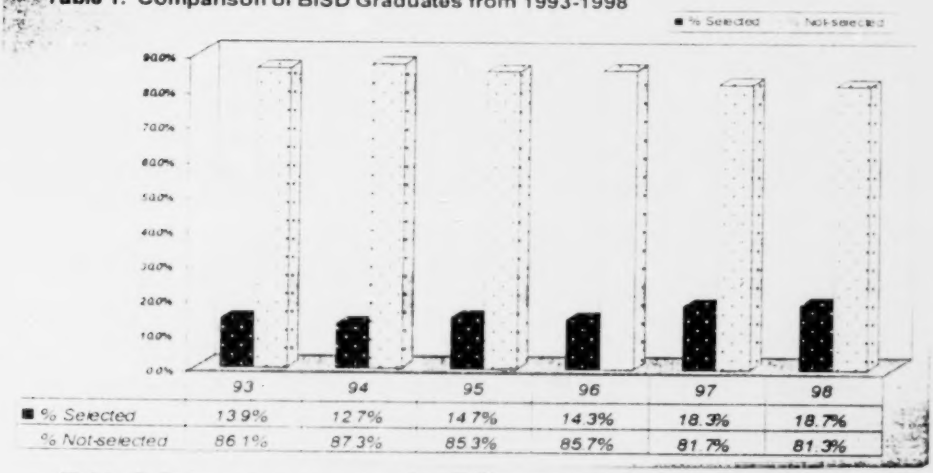
interventions include outreach programs geared to address Hispanic females, programs to attract young, energetic, and knowledgeable students into the teaching profession, and mathematics, science, and engineering programs designed to increase access and opportunity for young Hispanics. The following are brief accounts of these programs followed by longitudinal studies of SEM proficiency and by what students and teachers claim support recruitment and retention of Hispanics into the SMET pipeline.

The Brownsville Independent School District received a $2.5 million grant from the National Science Foundation to improve science and mathematics achievement among its 40,000 K-12 student population, 97% of which is Hispanic. Teacher training, curriculum reform, policy analysis, and student activities were part of a comprehensive plan to prepare and recruit minority students into the SMET pipeline. Over the five years, school-year and summer programs provided students with activities intended to increase their participation and preparation (Ramirez, 1998). The outcomes of the study used various indicators. Of interest is the level of science and mathematics preparation of students. This outcome indicator was termed SEM proficiency. SEM proficiency was obtained when students had acquired a predetermined set of mathematics and science courses upon graduation. If a student had taken and completed a mathematics sequence that included pre-calculus and a science sequence that included chemistry or physics, then the student was labeled as being SEM proficient. Hypothetically, if a student had graduated SEM proficient then their likelihood of success in post-secondary science, mathematics, engineering or technology programs would increase.

Over the five-year period researchers noted that graduates were slowly gaining SEM proficiency. Table 1. Comparison of SEM Proficiency of BISD Graduates from

1993-1998 illustrates the increase in SEM proficiency over a five year period. In 1993, 13.9% of Brownsville ISD students were found to be proficient. By 1998, the SEM proficient had increased to 18.7%. The number is still far below the expected outcomes, but an interesting trend regarding the difference in female graduate proficiency emerged.

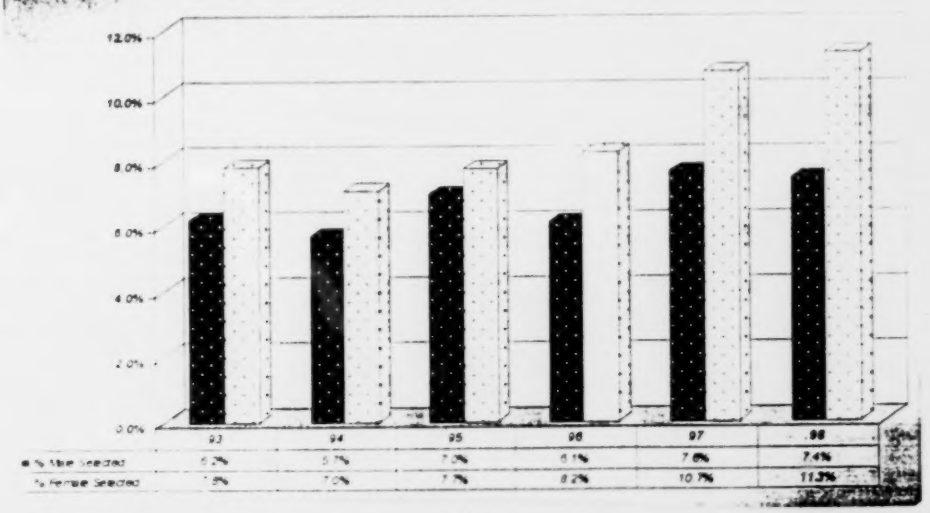
Table 1. Comparison of BISD Graduates from 1993-1998



	93	94	95	96	97	98
% Selected	13.9%	12.7%	14.7%	14.3%	18.3%	18.7%
% Not-selected	86.1%	87.3%	85.3%	85.7%	81.7%	81.3%

Table 2, below, compares gender differences in SEM proficiency of BISD graduates for the five year period. SEM proficiency for female graduates in 1993 were noted at 7.8%, whereas, male graduates were at 6.2%. By 1998, the SEM proficiency of

Table 2. Comparison of SEM Proficient of BISD Grades by Gender



	93	94	95	96	97	98
% Male Selected	6.2%	5.7%	7.3%	6.1%	7.8%	7.4%
% Female Selected	7.8%	7.0%	7.3%	8.2%	10.7%	11.3%

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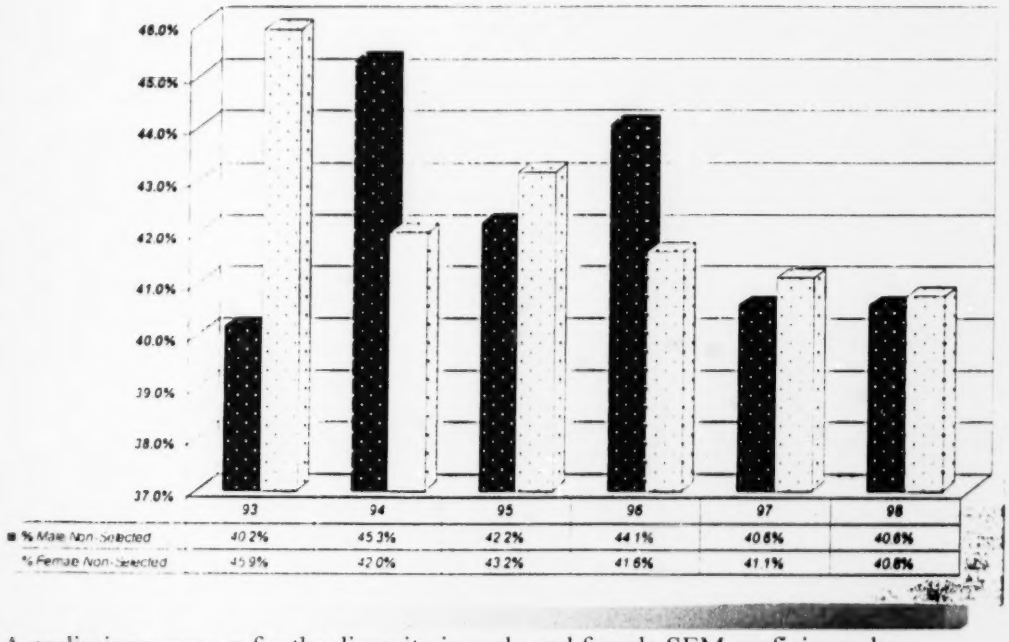
female graduates had risen to 11.3% while males had only made a 1.2% increase from the first year of the study.

From the onset SEM proficiency of female graduates was higher than their male counterparts. Table 3 below compares non-SEM proficient graduates for the five-year period by gender. In the first year of the study, the greatest disparity can be seen. As graduates participated in the NSF sponsored programs and other activities the disparity between male and females decreased.

Table 3. Comparison of Non-SEM Proficient Students by Gender



A preliminary reason for the disparity in male and female SEM proficiency has eluded researchers. Although a causal relationship may never be discovered, the relationship between several programs that intervened during the time-period are suspected in the increased proficiency of minority females.

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Some classrooms in schools may have become more female friendly. Recently, a male physics teacher provided an account of two situations that may become more commonplace in female friendly classrooms. In the first instance, he tells of two female students. The older was a senior and model Asian student who gained acceptance to the Massachusetts Institute of Technology (MIT). The teacher remembers the younger Hispanic female student explaining that if her friend could enter such a prestigious school that she would be able to enter also. The following year she joined her friend. Could it be that as female students see that they are just as likely to succeed as others before them, that they gain confidence and set goals that may be different from the norm? In another instance, the same teacher was assigned a physics class whose composition was entirely female. The students participated in laboratory activities and found that they had to rely on themselves to set up apparatus and calculate solutions to assignments. The teacher noted that in heterogeneously mixed classrooms these tasks were quickly taken by male students. Without males, the female students had to perform these tasks. The teacher insisted on not intervening when they were having difficulty. The teacher, after seeing the success of this arrangement, then structured his heterogeneously grouped classes to include homogenous, gender-based laboratory groups. Could more instances of homogenous grouping by gender have become more prevalent during the past five years? This philosophy may have been fostered later to other teachers since the teacher was assigned to coordinate and mentor school year and summer programs.

Over the past decade, many programs have influenced students, teachers, and the community. Their overall impact may be the key to changes in SEM proficiency. Further, in this case systemic factors may have been key to effect small, but significant,

changes in teaching and learning which have resulted in more Hispanic females taking science and mathematics coursework.

Addressing the Need for Hispanic Teacher Recruitment in Science and Mathematics

Beginning in 1996, the University of Texas at Brownsville and the Brownsville Independent School District joined into a venture to support an intervention to attract high-ability graduates into teaching, especially teaching science and mathematics. The program was named the "Quality Student/Quality Teacher Recruitment Academy." Sixty students from all five Brownsville ISD high schools were invited into the program. The original group of students included all students from the top ten percent of the class who had declared an interest to pursue teaching.

The students were invited along with the parents to attend several workshops and information sessions together. Each session included both students and parents. The sessions included information to cope with university life both from the student and parent point-of-view, seeking and applying for financial assistance, and establishing communication between parents and students while in college. This included a session with using e-mail and chat sessions.

After the joint sessions, students and parents were separated to attend to their individual needs. The parent sessions were conducted by university experts in parental involvement and university assistance programs. The parental involvement sessions expanded financial aid, helping students cope with being away from home, and ways of supporting student independence. The sessions were received positively. Although, parental participation varied, usually one of the parents attended.

Students attended sessions provided by university personnel. The sessions included a variety of personal management and education topics. In addition, students were required to observe and take part in the instruction of younger children. The student observations were coordinated between the principals of the cooperating high school and elementary or middle school campuses. The students discussed a variety of education issues and topics during the weekly evening sessions.

The students and parents used the information from their experiences during an annual conference for teachers, community leaders, and students called the "Celebration in Teaching Conference." The students and parents were given opportunities to communicate their experiences and the value of the intervention as part of the conference. Invited guests from universities, state agencies, and local school districts were given an opportunity to actively participate as speakers and as participants in sessions given by the students.

Conclusions and Recommendations. Rosser (1997) suggested 20 teaching techniques based on research in women's studies, ethnic studies, and science education which were used as a basis for recommending interventions to address the learning styles, socio-cultural behaviors, and appropriate policy and educational arrangements which benefit and include Hispanic females in science and mathematics. She suggests that we expand the kinds of observations beyond those traditionally carried out in scientific research. Women students may see new data that could make a valuable contribution to scientific experiments. Second, she believes that the number and duration of the observational stage of the scientific method be extended. This is consistent with our thoughts regarding how hands-on experiences with various types of equipment in the

laboratory may strengthen female students' confidence and understanding. We feel that female students would want to incorporate their personal experiences as part of class discussions or laboratory exercises. Teachers should key in on these experiences in both of these instances. Teachers should consider problems that have not been considered worthy of scientific investigation in the past. Although these problems may appear insignificant or trivial to male-centered thinking, women would want to explore these problems from their perspective. Further, formulating hypotheses focusing on gender as a crucial part of the question asked should be allowed exploration by females. Although difficult for traditional science teachers, there may be a need to undertake the investigation of problems from a more holistic, global scope than the more reduced and limited scale problems traditionally considered. Science teachers should also allow female students to use a combination of qualitative and quantitative methods in data gathering, along with allowing the use of methods from a variety of fields or interdisciplinary approaches to problem solving. Teachers could also use more interactive methods, thereby shortening the distance between the observer and object studied. The use of precise, gender-neutral language in describing data and presenting theories should be continually on the minds of teachers. They should also be open to critiques of conclusions and theories drawn from observations differing form those drawn by the traditional male scientists from the same observations. As was noted earlier by our observations, the use of less competitive models to practice science by structuring classroom assignments and arrangements should be practiced by teachers. Finally, teachers should place increased effort into strategies such as teaching and communicating with nonscientists to break down barriers between science and the lay person.

Science and mathematics may not appear different to males and females in others minds. However, the way we have approached teaching and learning, may gain acceptance in some circles. Teachers must consider the possibility that from an educational perspective, we must attempt all strategies that may yield success by all groups--especially Hispanic females.

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